

Hangloo

HISTORY of SCIENCE and TECHNOLOGY



HISTORY of SCIENCE and TECHNOLOGY

Exploring New Themes

Edited by

Rattan Lal Hangloo





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Hydraulics and Water Management at Fatehpur Sikri¹

Syed Ali Nadeem Rezavi

The remains of Fatehpur Sikri situated as it is on a ridge supply us some vital clues to the science and techniques of water management and hydraulics during the medieval period in north India. As a rule the pre-modern settlements generally grow around some major source of water, such as a river, lake or pond, which would not only act as a source of potable water, but also provide a barrier for security. Also it is generally observed that within a settlement, the areas closer to the source of water were reserved for the more influential sections of society. This may be seen at Delhi, Agra, Ahmedabad and Cambay. It is in this light that we may study the layout and water supply system at Fatehpur Sikri.

Before the founding of Fatehpur as a capital city, the village of Sikri was a "well-watered" ground which could sustain a large army. Babur testifies to the abundance of water at Sikri (on the plain by the side of the lake) when he mentions the Kol lake near this village.² When in AD 1571-72 orders were issued by Akbar to construct the city of Fatehpur, the major elements of the town were planned not around this lake, but on the broad top of the ridge and on the plain towards the south of the ridge. The scheme of placing the important structures and influential sections along the banks of the water reservoir was not followed at Fatehpur Sikri. Abul Fazl specifically mentions that the lake (*golābi*) was situated 'below the town' (*pīwast-i-shahr*) on whose banks "His Majesty constructed a spacious courtyard (*saffa*), a *minār* and a *chaughāngāh* (polo ground), where elephant fights are organised".³ Our sources however reveal that the lake of Fatehpur Sikri remained the major source of water

supply to the city. Fr. Monserrate who visited the city in 1580–81 with the first Jesuit Mission says:

To supply the city with water a tank has been carefully and laboriously constructed two miles long and half a mile wide. The work was performed, by the King's direction ...⁴

A survey of the dry bed of the lake in Sikri reveals that though it is formed by a natural depression of the ground between the Sikri ridge on the south and certain spurs in the north-west near the village of Rasulpur, it was regulated by the construction of two barrages, viz., the *Terah Mori* and the *Bāwan Mori*. The *Terah Mori* barrage, situated exactly to the north of the lake, on the Agra-Bharatpur road comprises thirteen arches which contained wooden sluices to release the excess water. To the north east of it is constructed the more heavily built barrage now popularly known as the *Bawan Mori*, which as the name suggests once comprised fifty two sluices. This earthen barrage forms the limit of the lake towards the old township of Nagar. The excess water released from these barrages flowed into a rivulet which then passed on towards the east, crossing the Agra-Sikri road near the town of Kirauli. This rivulet provided water to the area situated to the east of Fatehpur Sikri. The lake was fed through two sources, a channel drawing in the Utangan River, now known as Khari Nadi, and rain water. It appears that these barrages and dams which regulated the natural lake were constructed by Akbar in AD 1579. In a letter to Fr. Peres written in AD 1580, Fr. Henrique, a member of the Jesuit Mission reported:

... about a year ago, in order to improve the city, water has been led in from somewhere to form a sizeable lake which is perennial. All the elephants, horses and cattle drink from it, and it also serves the teeming population for all purposes.⁵

Fr. Monserrate is however, much more explicit:

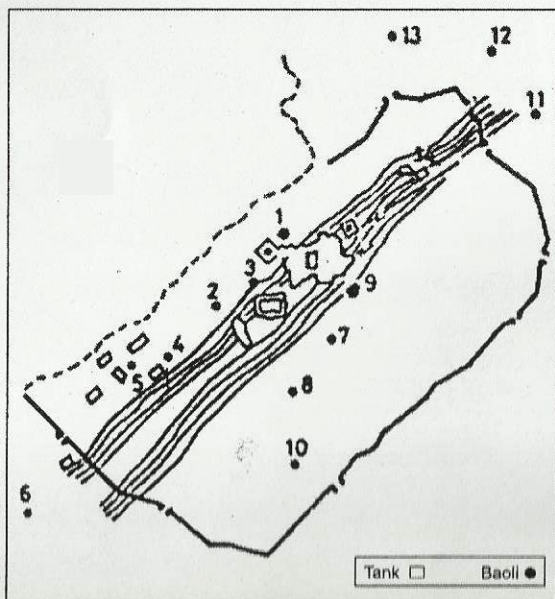
Across to the end of a low-lying valley which was filled with water in the rains, (although the water afterwards drained away or dried up), a great dam was slowly built. By this means not only was a copious supply of water assured, but the discomfort of the climate was mitigated.⁶

It is interesting to note that our sources vary when they discuss the size of this lake, though all agree that it was very large. In 1580 Fr. Monserrate, mentions it to be "two miles long and half a mile wide". In 1610, when William Finch visited Fatehpur Sikri, he found it "2 or 3 cos in length".⁷ Nine years later, in 1619 when Jahangir ordered it to be measured, and found it's circumference to be 7 *koss*.⁸ Later in 1633, Peter Mundy reported it to be "10 or 12 mile

long".⁹ Though these statements vary, they can partly be explained by the seasonal changes in the volume of water and partly by the vulnerability of the subjective estimation. But it is clear that at least until early years of Shahjahan's rule lake had maintained its extremely large size.

The demand for potable and irrigation water was also taken care of by digging a large number of wells (*chāh*) and constructing a number of *bāolis* (step wells) scattered all over the town. While interviewing a number of senior residents of Sikri, Nagar and Fatehpur during the course of my survey in the first week of March 1996, my informants spoke of the existence of as many as 52 *bāolis* and 108 masonry wells till the fourth decade of the present century. The survey of the area however revealed 14 step wells and over 60 wells, were all there when Fatehpur Sikri was built.

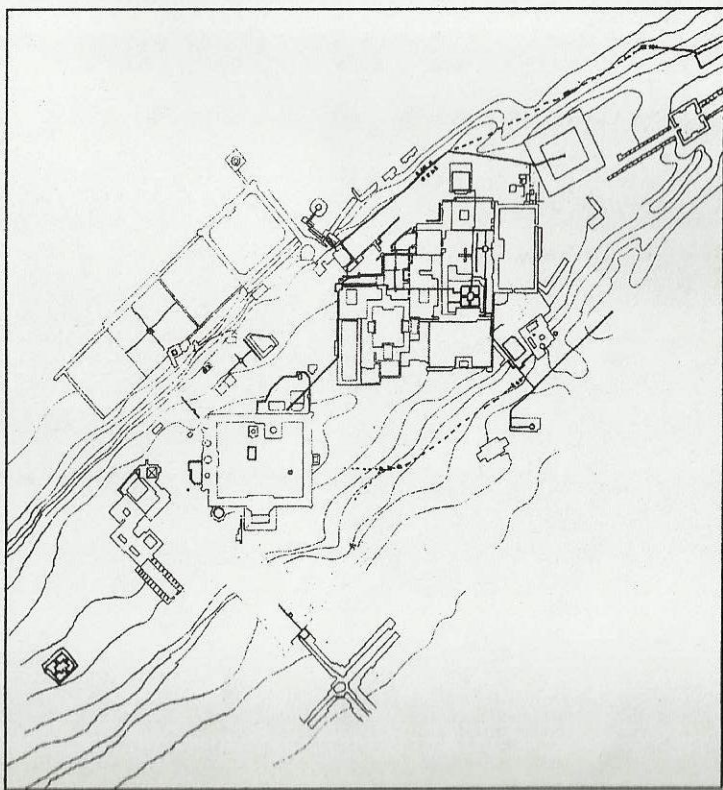
Among the step wells or *bāolis* which were located during the course of the survey, some were in a very dilapidated condition. Since these may soon disappear, it is worth recording them here: (1) Octagonal *bāoli* below the Hathipol; (2) Indārawali *bāoli* in the Indara Valley; (3) Shahjahani *bāoli* in the garden to the west of Hathipol Sarai; (4) a *bāoli* to the west of Babur's Bagh-i-Fath (only traces remain); (5) a *bāoli* near the so-called 'Matiya Mahal', near the Qush Khana (only outlines visible); (6) the four-storied grand *bāoli* around



Sources of Water Supply

300 metres outside Ajmeri Darwaza; (7) Moti Bagh *bāoli*, now in the main bazar of Fatehpur, adjacent to the northern Gate of the four-laned Akbari *bazar*, popularly known as 'Pukhta Sarai'; (8) a *bāoli* in Muhalla Katra, near Purana *Dāk-khāna*; (9) Shah Quli's *bāoli* near the so-called 'Hakim's Baths' (the Imperial Baths); (10) a *bāoli* near the Gwalior Darwaza, adjoining a *Chahārbāgh*; (11) a *bāoli* around 300 metres outside Agra Darwaza, on the Agra road, (besides the modern wine-shop); (12) a *bāoli* to the east of the Agra-Bharatpur Road, outside the Lal Darwaza; (13) a *bāoli* to the north of the Bharatpur-Agra Road towards Nagar; and (14) a *bāoli* to the north-west of the Buland Darwaza, popularly known as the *jhālra*.

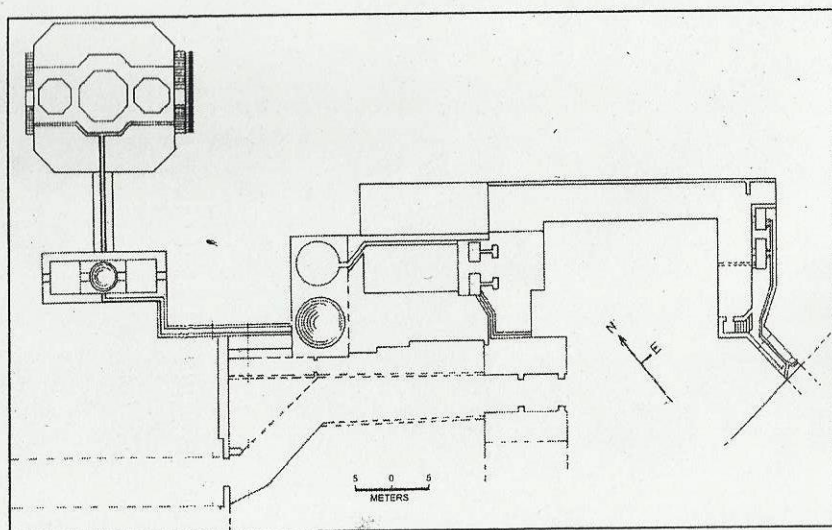
As can be seen from the appended plan depicting the placement of the sources of the water supply, these step wells were fairly evenly located all around the medieval settlement of Fatehpur Sikri. The survey further revealed that nearly all these *bāolis* (except Nos. 4 and 5) still contain water, and need only minor repairs to make them



Distribution of Water

functional. Out of these 14 *bāolis* which could be located so far by the author, eleven belong to Akbar's period; one (No. 12) pre-dates the Mughals, to judge from the carving of the stone, probably a remnant of the Sikriwal Rajput rulers. Another belongs to Babur (No. 2). Baoli No. 3 was constructed during the reign of Shahjahan. Five of them (Nos. 1, 2, 7, 9, and 14) have octagonal wells, while the rest are square. Apart from being a regular source of potable water, these step wells also acted as pleasure resorts where the weary travellers could rest.

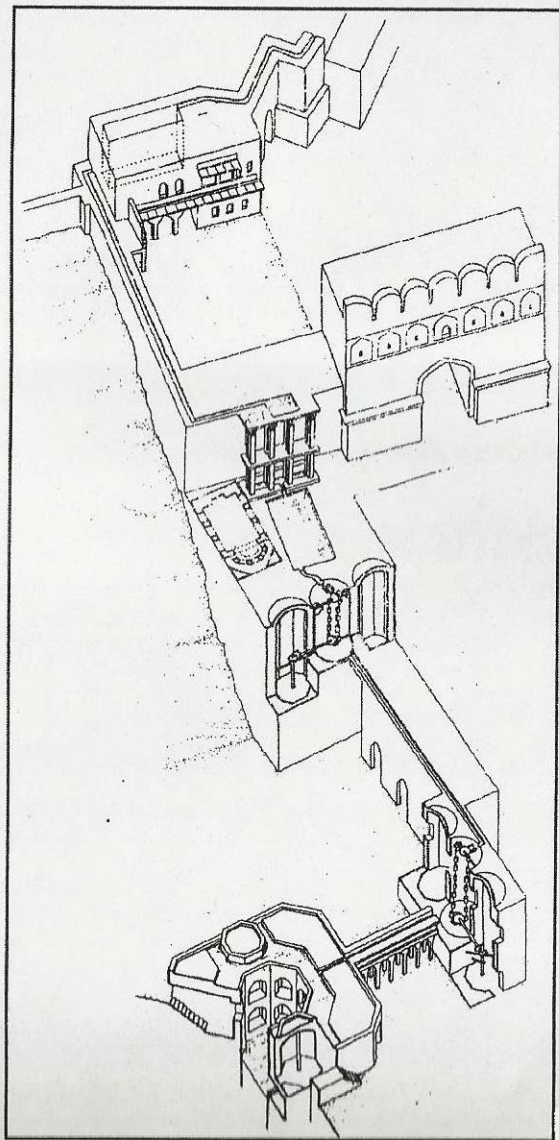
Apart from the major tanks in the palace complex, around six rectangular and one square tank (*hauz*) to store water were also located during the course of the survey. Of these, five were found in the so-called Indārā Valley, near the Ajmeri Darwaza, an area reserved for pleasure resorts and gardens. The sixth water tank is located in the residential area reserved for the nobility on the north eastern spurs of the ridge. This tank, which has recently been discovered, is situated between the nobles' quarters and the rows of excavated shops of the *Bāzār-i buzurg-i Sangīn* (the large stone market). This was a very large water tank to meet the needs of the houses of the nobles, the market, as well as the *sarā'i* located near the Agra Gate.



Northern Water Works (Hathi Pol)

The square water tank is situated atop the ridge on the extreme west, at a distance mid-way between the old Chishti quarters and the *Chor Khirki*. A modern cremation ground is situated adjacent to this tank. This tank resembles the *Anūptalāu*, in many of its features situated in the *Daulatkhāna*. Constructed with rubble stone, each side

of this tank is provided with steps. In the centre is a square platform which is connected with a cause-way on all the four sides. It is interesting to note that all around this tank are the ruins of structures, which unfortunately have yet to be studied. The area also yielded a large number of low and medium quality blue ware sherds.



Northern Water Works: Elevation

Water harvesting appears to have been the major objective of the tanks situated on the top of the ridge. The major source of water for these tanks was rainwater which was harnessed into them through slopes and channels. We have the testimony of Abul Fazl that rainwater mixed with Ganges water was used to prepare food in the Royal Kitchen.¹⁰ A survey of the existing water channels confirms this statement. The tank situated near the *matbakh* (Royal Kitchen) and the office (*yātishkhāna*) of Muhammad Baqir *Sufrachi*, the superintendent of the kitchen establishment was, and still is, filled by the rainwater falling on the courtyard of the *Daulatkhāna*. Constructed on the tapering spurs of the ridge, this tank, popularly known as the '*Hauz-i-Shirīn*' (the sweet water tank), is raised on vaults.

Similar harvesting of rainwater appears to have been resorted to in the Jami Masjid Complex. The water falling on the floor of the Mosque as well as the Tomb of Shaikh Salim Chishti was collected in an underground covered water-tank (*birka*) constructed by the walling up of the vaults forming the courtyard of this mosque. Water from the ceiling of the mosque was directed to the octagonal *bāoli* and tank (*jhālra*) situated to the west of the Buland Darwaza.

The tanks situated in the plain (e.g., the Indara Valley) were, on the other hand filled by drawing water from the wells situated nearby. The survey revealed some of the water channels connecting the tanks with their wells.

The real feat of hydraulic engineering is however revealed in the elaborate system of lifting the water from the ground level to the top of the ridge where the palace complex, the nobles' quarters and houses of the main civic population were located.

A survey of Fatehpur Sikri reveals that the imperial system of water supply was divided into two sections – the Northern Water Works, situated near the Hathipol and the Southern Water Works, near the Hakim's Baths. These water works were apparently designed to meet the entire need for water in the palace complex as well as the town of Fatehpur Sikri.

The Northern Water Works appear to be more elaborate and technically sophisticated. We are fortunate that Peter Mundy gives a very precise description:

The kings' house or Moholl stands on the highest hill, within which are abundance of courts, conveyances, galleries, chowtrees (*chabutra*), arches, pillars, tanks, chaboochaees (*chahbacha*), private rooms, all very rich, curious, and full of invention of paintinge, carvinage, etts; also a little garden. *The water to water it is also to fill*

*the tanks alofte, and for their use is drawn from the valley, first into one tank and then from that into another higher, and so into 4 or 5 untill it came aloft, by that which wee in Spaine call Noraies.*¹¹

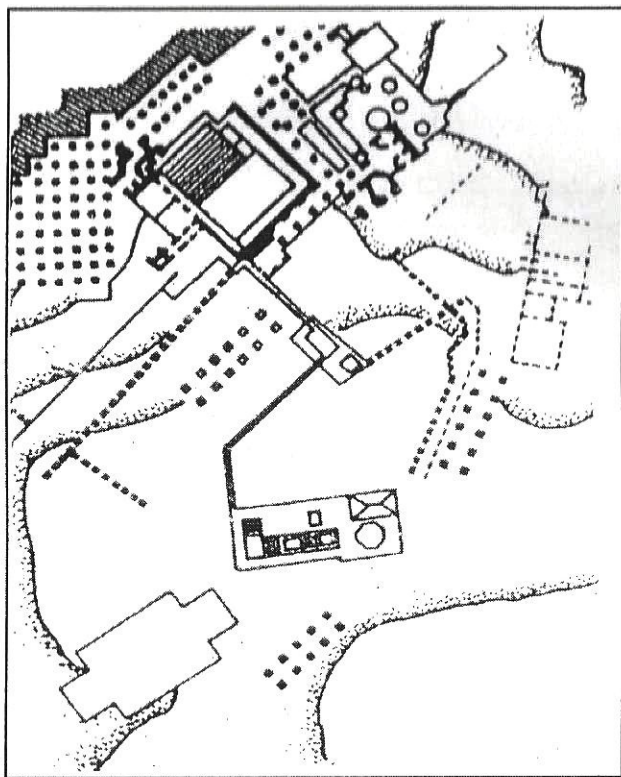
At the first stage, the subterraneous water was raised through the construction of an octagonal *bāoli* below the Hathipol. This *bāoli* is shaped in the form of an irregular octagon, a chamfered square, with each of the principal sides measuring 15.45 metres. The chamfered sides of the octagon have lengths of 4.60 m. In the middle of this structure is an octagonal well with each side 2.90 m in length. To the north and south of the well are placed two octagonal chambers, the raised vaulted ceilings of which are visible as octagonal platforms from above. A 0.23 m wide water channel carried the water from this *baoli* to an artificial well situated to its west. This water channel runs on top of a 12.15 m long and 2.55 m broad aqueduct.

The artificial well (*chāhbachāh* or *chāh-bachcha*, receiving water from another well) which acted as the second stage for lifting water is a rectangular structure with two vaulted chambers flanking the circular well on two sides. The well itself is 10.6 m deep and 3.96 m in diameter. From here a water channel (0.23m in width) took the water to a second storage well, which is again flanked by two vaulted chambers. Between the two storage wells, the water was carried to an approximate distance of 10.50 m. The water brought to this second storage tank was then lifted to a large rectangular tank situated towards the south. A water channel then emptied the water into another rectangular trough constructed at the level of the floor of the Hathipol. Until this stage the water was raised to an approximate height of 30 metres from the ground level.

Just above the water trough projecting spaces are constructed to raise the water further to the fourth stage atop the roof of the quadrangle to the east of the Hathipol. A set of aqueducts diverted the water from this roof to the two storage tanks constructed on the first floor of the structure flanking the second gateway after the Hathipol. From here the water was again raised to a fifth stage, and, through a channel running atop the gateway entered the *haramsara* complex through the north-western corner of the so-called "Birbal's House" quadrangle (the first Imperial Palace).

Another branch of the water channel took the water through the northern walls of the Hathipol *daftarkhāna* to the bureaucratic establishments constructed below the *hauz-i shērīn*.

A question which arises at this stage is, how the water was raised to the succession of the *chāhbachāhs*. We have already quoted Peter Mundy wherein he mentions the use of 'Noraies'. Bishop

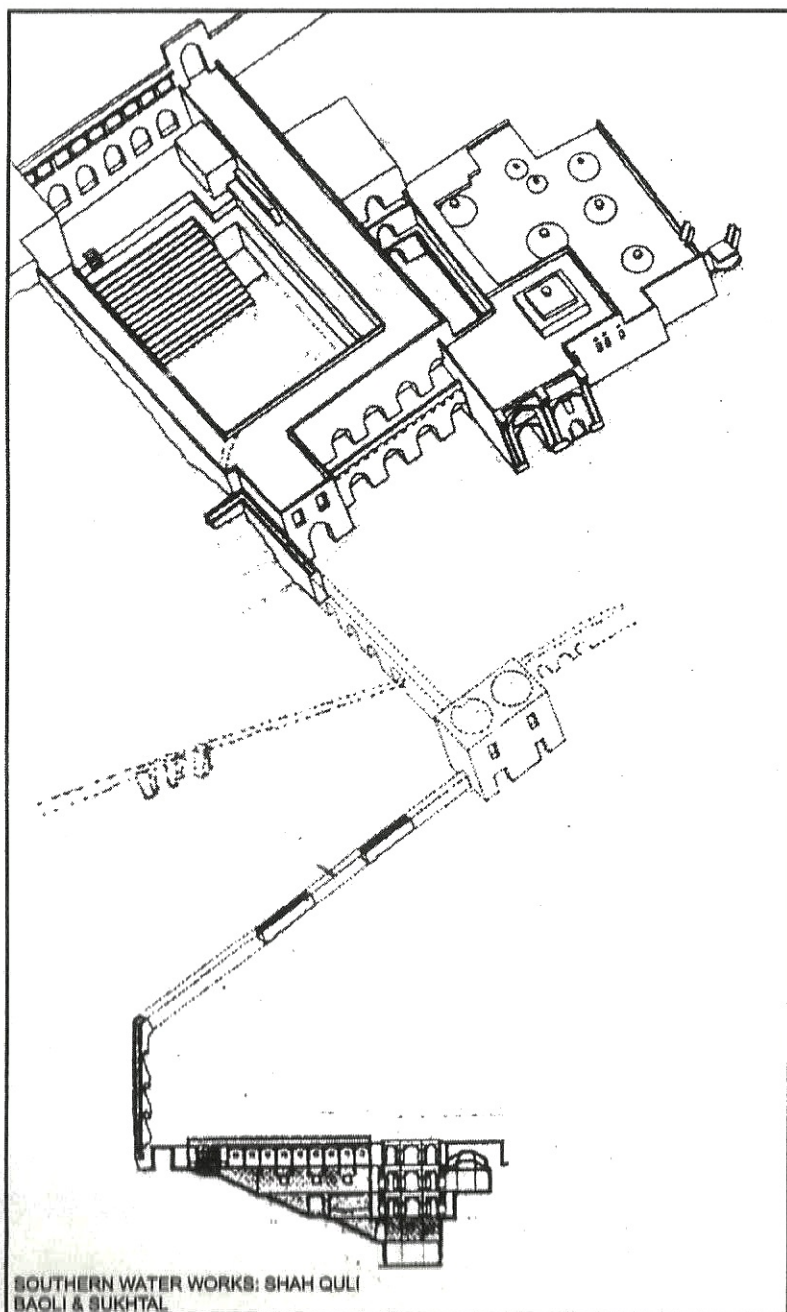


Southern Water Works (Hakim's Baoli & Quarters)

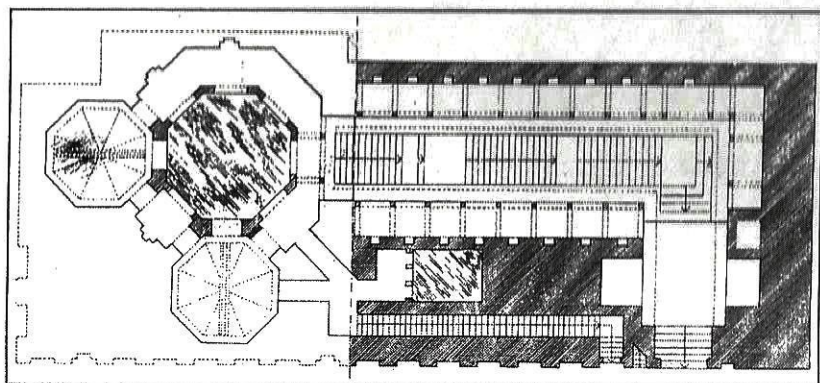
Heber visited Fatehpur Sikri in AD 1825. Describing the water works, although confusing its location and attributing it to be adjoining the Jami Masjid, he writes:

... and the whole hill on which the palace stands bears marks of terraces and gardens, to irrigate which an elaborate succession of wells, cisterns, and *wheels* appears to have been contrived adjoining the great mosque, and forcing up the water nearly to the height of its roof. The cisterns are still useful as receptacles for rain-water, but the *machinery* is long since gone to decay.¹²

Two *Akbarnama* paintings depict this water lifting device which was used to raise the water in the northern waterworks. (See plates 1 and 2) The first miniature, which was designed (or outlined; *tarah*) by Tulsi and painted (*amal*) by Bhawani, depicts a Persian wheel drawing water from a well near the Hathipol, which is under construction.¹³ The second depicts Persian wheels at two stages near the Hathipol.¹⁴



Southern Water Works (Hakim's Baoli & Quarters): Elevation



Shah Quli's Baoli (Hakim's Baoli): Plan

The Persian wheel, as we know, was a device which was based on the technique of pin drum gearing. It comprised of a wheel, fixed on the mouth of the well, which contained a string of pots (*māla*). This wheel atop the well was connected with a second wheel through a shaft. The second wheel fitted with wooden pegs (pins) was rotated vertically by horizontally rotating a pin drum (i.e., a double-drum, the two layers of which are joined at the rim by pegs placed at the same distance as on the rim of the other wheel). The horizontal motion to the drum was provided through draught animals harnessed to it through a shaft. According to Abul Fazl Akbar had invented a way of raising water to a great height from a low level through the water, wheel. To quote:

His majesty made such water wheels (*daulāb-ha*), and such (gear) wheel (*gardūn-ha*) were fixed thereon, that water may be carried to a height from distant low-lying places.¹⁵

This was due to his placing the pin drum at a much higher level than the draw bar of the oxen turning round the axle. This meant that the water would be drawn up through the chain of pots to a height considerably above the oxen, where the mouth of the receiving aqueduct could now be placed. It happens that two paintings in Nizami's *Khamasa*¹⁶ prepared in Akbar's atelier illustrate such a device.

A closer look at the octagonal *bāoli* of the northern water works and its storage wells reveals the provision of stone shafts which once held the vertically rotating wheel of pots. The draw-bars which rotated this wheel were placed in the two vaulted chambers, which we have noted, flanked the well in the *bāoli* and the two storage wells. Similarly, protruding stone beams fixed atop the rectangular cavities near the Hathipol lifted the water atop the roof of the eastern

quadrangle. Thus, we see that the northern waterworks was a complex of storage tanks, storage wells and Persian wheels which helped the water to be raised at five stages to reach the level of the Imperial complex atop the ridge.

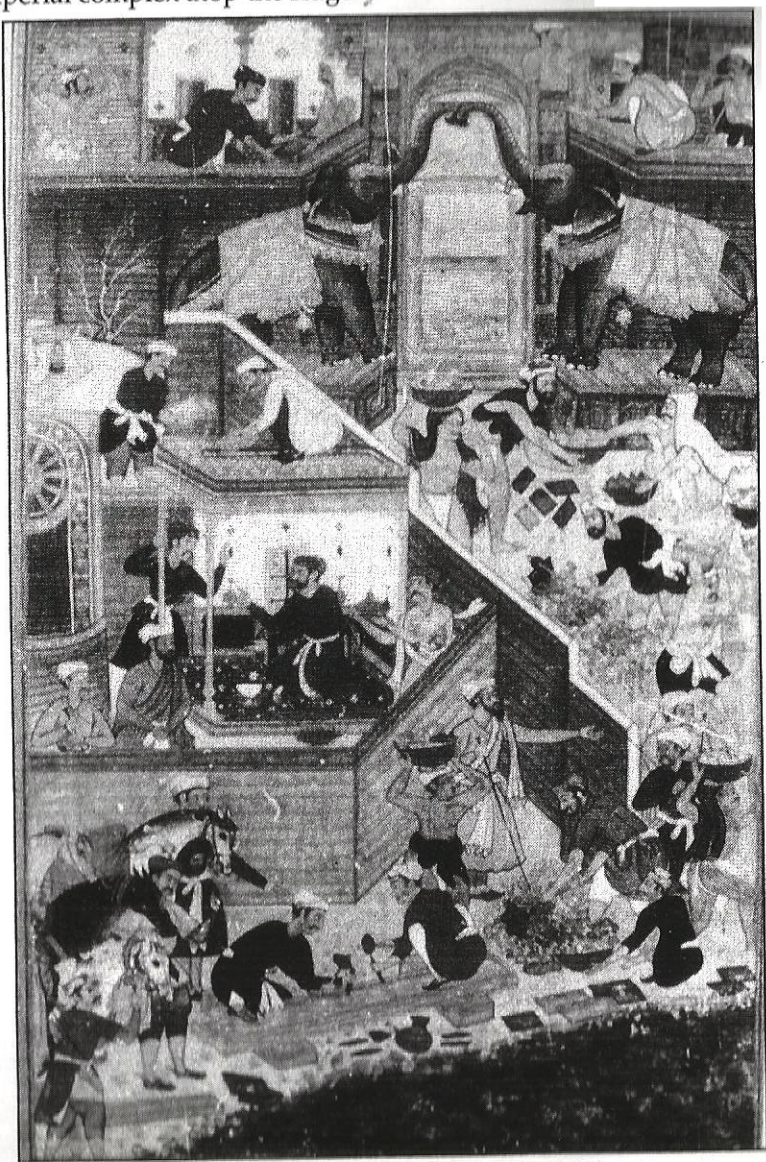


Plate 1: "The Construction of Fatehpur Sikri", *Akbarnāma*,
MS. V & A Museum, London, IS 1-1896, f. 86/117

The southern waterworks which centred on the *bāoli* attributed to Shah Quli, near the Hakim's Baths, survive in a much more dilapidated condition. From here the water was supplied not only to the *daulatkhāna* but also to the civic population living in the areas south of the ridge.

Shah Quli's *bāoli* appears to be the largest step well at Fatehpur Sikri and comprises of three storeys surrounding the octagonal well. Water drawn from this step well with the cutlasses fixed in the two chambers adjoining the well, was carried through ducts to a raised storage tank situated in front of the Hakim's Baths. From here the Persian wheels lifted the water, which was then distributed through aqueducts into three directions, the north, east and west. In the north, the water emptied into a tank situated near the massive '*Sikh tāl*' adjacent to the Imperial Baths, from where it was taken to the Baths and garden of the *daulatkhāna*.

In the area between the southern wall of the *daftarkhāna* and Shah Quli's *bāoli* a number of piers which once carried water ducts still survive. Similar aqueduct appear to have been constructed to the east of the storage well. During the course of the survey, bases of two such piers were encountered.

The water thus supplied from the northern and southern waterworks to the Imperial complex was distributed to various sections through the conducts running between the wells. Unfortunately, we encounter a number of gaps in these channels running through the Imperial complex. This is probably due to the renovation work which was undertaken under Lord Mayo and Lord Curzon. A look at the appended map would however point out that still enough evidence survives to connect the various palace complexes. The map would also suggest that the major supply to the Imperial complex was through the northern waterworks, whereas the southern waterworks catered mostly to the needs of the civic population, a function which it still performs.

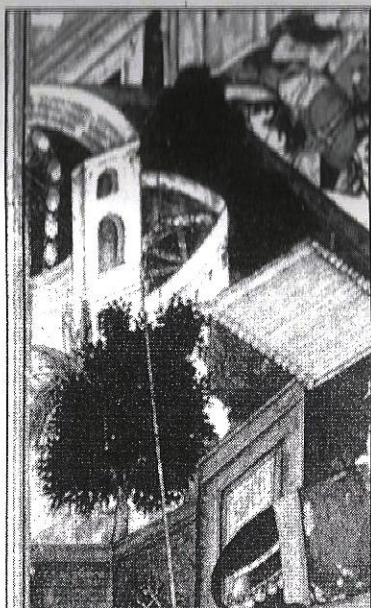
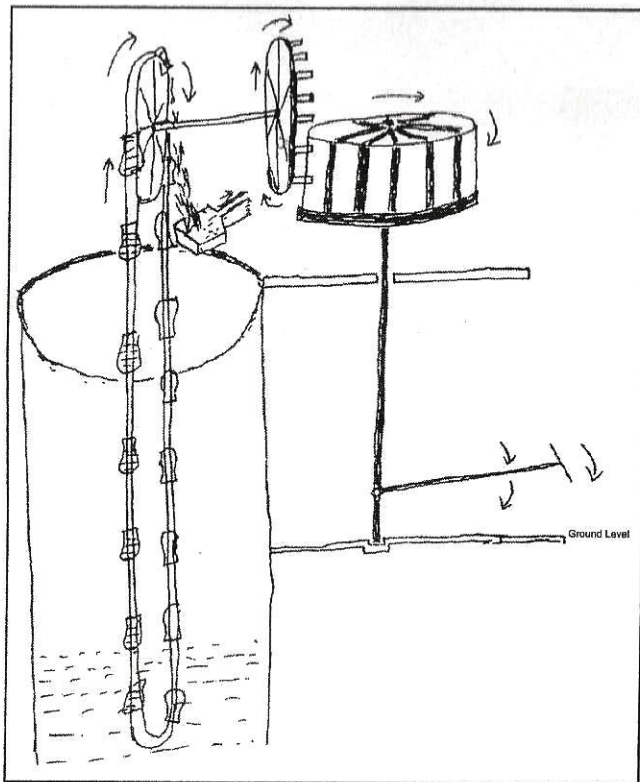


Plate 2: "Akbar returns to Fatehpur Sikri from Gujarat", *Akbarnāma*, Ms. V & A Museum, London, IS 1-1896, f. 111/117.

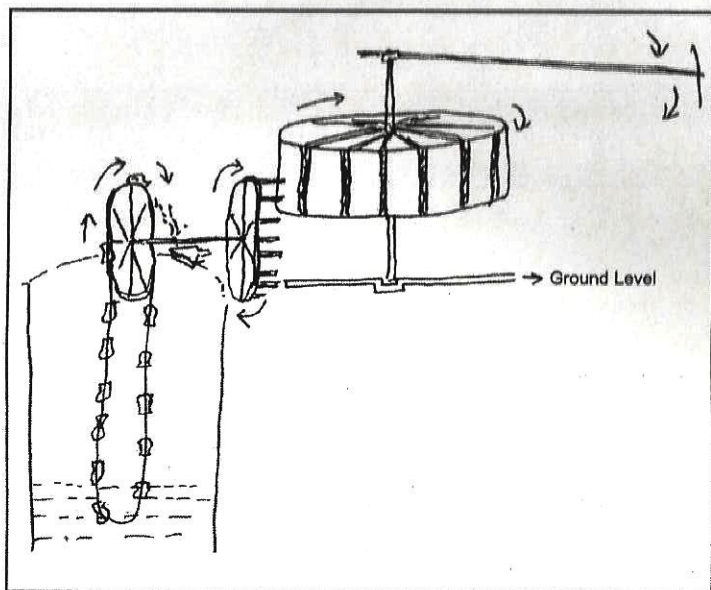


Persian Wheel as Depicted in Khamisa of Nizami

Apart from the *bāolis*, wells and tanks, a number of piers of the aqueducts survive around the city of Fatehpur which gives us some idea of how water was carried from one area to another. For example a series of such piers survive in the area below *hauz-i shūrīn*, on the slopes of the northern ridge, below the so-called Tansen's Baradari and the excavated residential structures. These piers carried the aqueducts which connected the northern works with the large water tank situated near the nobles' houses, as mentioned earlier. This massive tank is 28.10 m. wide and 67.40 m long. Probably the entire needs of the eastern area were met through the water stored in this tank.

It is also important to note that the individual residential structures, which have been excavated at Fatehpur Sikri in most cases, seem to have had their own water storage tanks.

There are still areas in Fatehpur Sikri, for example the areas in the south-west about which not much is known. A number of wells



Persian Wheel

survive in that region, but they appear to be insufficient to cater to the entire needs of the population who must have settled there. The water must have been carried from here to individual houses through water-carriers.

Notes

1. This article was originally presented as a paper at a Seminar on Archaeology of Medieval India held by the Centre for Archaeological Studies and Training, Kolkata in 2001.
2. A.S. Beveridge (tr. and ed.), *Baburnama*. New Delhi, 1970, pp. 548–88.
3. Abul Fazl, *Ain-i Akbari*. Vol. II, Nawal Kishore, Lucknow, 1882, p. 84. Our surveys on the banks of the lake have also revealed only pleasure resorts, pavilions and gardens in the area between the ridge and the lake.
4. Fr. Monserrate, *The Commentary*. J.S. Hoyland (tr.) and S.N. Banerjee, Delhi: OUP, 1922, p. 31.
5. Letter from Fr. Henrique to Fr. Peres, *Letters from the Mughal Court: The First Jesuit Mission to Akbar (1580–1583)*. J. Correia-Afonso (ed.), Bombay, 1980, pp. 22–23.
6. Fr. Monserrate, op. cit., p. 31.
7. William Finch, *Early Travels in India: 1583–1619*. W. Foster (ed.), Oxford: Oxford University Press, 1921, p. 150.

8. Saiyid Ahmad (ed.), *Tuzuk-Jahangiri*. Ghazipur and Aligarh, Delhi, 1864, p. 259.
9. Peter Mundy, *Travels in Europe and Asia 1608–1667*. R.C. Temple (ed.), Vol. II, London: Hakluyt Society, 1907–36, p. 230.
10. *Ain*, op. cit., I, p. 22.
11. Peter Mundy, op. cit., II, p. 228.
12. Bishop Heber, *Narrative of a Journey through the Upper Provinces of India from Calcutta to Bombay, 1824–25*. Vol. II, London: John Murray, 1828 p. 353.
13. 'The Construction of Fatehpur Sikri'. *Akbarnāma*. Ms. V & A Museum, London, IS 1–1896, f. 86/117.
14. 'Akbat returns to Fatehpur Sikri from Gujarāt'. *Akbarnāma*. Ms. V & A Museum, London, IS 1–1896, f. 111/117.
15. *Ain*, op. cit., I, p. 199.
16. Ms. British Museum, Or. 12208, ff. 65 (a), 99 (b).